

Technical Efficiency and Fishing Skill in Developing Country Fisheries: The Kedah, Malaysia Trawl Fishery

K. Kuperan Viswanathan, International Center for Living Aquatic Resources Management (ICLARM)
Yongil Jeon, University of California, San Diego, Harvard University
Ishak Haji Omar, Universiti Putra Malaysia
James Kirkley, Virginia Institute of Marine Sciences
Dale Squires, U.S. National Marine Fisheries Service, University of California, San Diego
Indah Susilowati, Diponegoro University, Indonesia

Abstract: The question arises for fishery managers as to whether or not there are observable and measurable attributes of the skipper or vessel that fishery managers can monitor and possibly regulate to control expansions in fishing capacity from this source. This paper addresses this neglected issue of resource management through a case study of the trawler fishery in the state of Kedah in Peninsular Malaysia. In the Kedah trawl fishery, skipper characteristics other than ethnicity did not significantly affect technical efficiency and skipper skill. Hence, there does not appear to be any readily observable characteristics pertaining to skipper skill to monitor and regulate. This finding militates against regulating skipper skill to control expansions in fishing capacity that can happen under license limitation. The results indicate that a skipper training program for the least efficient skippers may be called for to meet the objectives of equity and fairness as expressed in the New Economic Policy and its successor, the New Development Plan. Such a training program would also be consistent with one of the initial aims of the license limitation program, which was to promote equity among all ethnic groups in Malaysian society.

Key words: technical efficiency, fishing skill, Kedah, Malaysia, trawl fishery, equity.

1. INTRODUCTION

The predominant form of regulation in Asian developing countries' fisheries is some form of area license limitation, which limits the number of vessels in different fishing zones.¹ India, Malaysia, Indonesia, and the Philippines all regulate their large-scale commercial fisheries in this manner.

Limiting the number of vessels can help cap fishing capacity, but capacity can still expand by several other means, thereby continuing to place pressures upon resource stocks and dissipate rents. Fishing capacity can increase by expansions in unregulated inputs (Pearse and Wilen 1979) or productivity growth (Squires 1992). Fishing capacity will also not be capped to the extent that the production capabilities are related to fishing skill and not only the directly observed and controllable inputs (Hilborn and Ledbetter 1985). This fishery management problem arises because the most capable skippers tend to remain in a fishery, since they can earn intra-marginal rents, and also because as the resource stock and rents begin to rebound under effective management, the most capable skippers can expand their catches faster than other skippers. Skipper managerial abilities are not directly observable and hence are beyond the control of fishery managers.

Skipper skill or vessel managerial ability has most often been defined as the ability to consistently catch the most fish given the vessel, crew, and other inputs (Barth 1966, Palsson and

Durenberger 1982, Thorlindsson 1988). This definition is precisely that of technical efficiency in fisheries (Kirkley, Strand, and Squires 1988, Squires and Kirkley in press).

The question arises for fishery managers as to whether or not there are observable and measurable attributes of the skipper or vessel that fishery managers can monitor and possibly regulate to control expansions in fishing capacity from this source. This paper addresses this neglected issue of resource management through a case study of the trawler fishery in the state of Kedah in Peninsular Malaysia. The balance of the paper is organized as follows. Section 2 discusses skipper skill, the specification of management in production technologies, and technical efficiency. Section 3 gives a background to the fishery. Section 4 specifies the empirical model. Section 5 provides the empirical results and Section 6 offers concluding remarks.

2. SKIPPER SKILL, MANAGEMENT, AND TECHNICAL EFFICIENCY

In summarizing the anthropological literature on skipper skill, Thorlindsson (1988) observed that there are two notions of the skipper effect. First, numerous authors have argued that any skipper effect should be consistent, giving a relatively stable comparative ranking of fishing success across time (Barth 1966, Palsson and Durenberger 1982). Captains performing

well in one season should perform well in the following season. Second, the other notion of the skipper effect is based on the performance of individual skippers. This second notion does not require a stable hierarchy of fishing success, but rather only a few noteworthy skippers with the catch more or less randomly distributed between the rest of the captains. In a dissenting view, Pålsson and Durrenberger (1982) found evidence that a skipper effect accounted for only very little unexplained variance of catch rates between vessels in Iceland. They argued that other factors, such as vessel size and time spent fishing, are instead important.

Barth (1966) stressed that the decision on where to search for herring in the Norwegian herring fishery is the first and most important decision affecting the size of the catch. Acheson (1981) identified three components of skipper skill: (1) the ability to accurately navigate to find the best grounds; (2) good knowledge of the ocean, such as its currents, depths, and types of bottom; (3) and good knowledge of the species of concern. Thorlindsson (1988) identified three additional components: (1) the ability to “read the sea” and its ecological environment; (2) the willingness of the skipper to search independently and to take calculated risks, which is probably a function of many factors; and (3), the ability of a skipper to lead and manage the crew.

In fishing industries, skipper skill is related to finding and catching fish, knowing or sensing when to leave a spot for another, managing and supervising crew, responding to breakdowns in equipment and machinery, response to changing tides and weather, seasonal variations in resource abundance, and numerous other factors. By the time a captain has decided when to make a fishing trip, the crew size, gear type, and likely fishing areas have already been decided. Thus, the captain's options for changing the levels of inputs can be severely limited. The skipper must make do with the available resources and be able to readily change in response to changing circumstances (e.g., finding a “hot-spot” or large concentration of high-valued fish). The skipper must regularly inspect the gear after nearly every “haul-back” to prevent unnecessary gear damage and the subsequent loss of fish. All in all, in this hunting production process, it appears that skipper skill or managerial ability is more indicative of the ability of a vessel captain to find fish and to readily change operations in response to unforeseen changing circumstances rather than make changes in input levels.

Skipper skill may also be related to minimizing risk and uncertainty. Pålsson and Durrenberger (1982) suggested that skippers avoid seeking high catches with low probabilities, and instead seek high probabilities of some catch, even if a small one.

Skipper skill has been equated to technical efficiency by Kirkley, Squires, and Strand (1998). Squires *et al.* (1998) examined attributes of the captain and vessel potentially

affecting efficiency for artisanal gill net fisheries on the east and west coasts of Peninsular Malaysia. They found that the skipper characteristics were generally statistically insignificant in both fisheries as variables explaining technical inefficiency. Along a similar vein, Pålsson and Durrenberger (1982) found no relationship between skipper experience and catch rates (as opposed to technical efficiency). Acheson (1975), reporting the results from a regression analysis, indicated that skipper age was not a good surrogate variable for fishing skill, and that education was marginally statistically insignificant.

3. THE KEDAH TRAWL FISHERY²

The fisheries of Peninsular Malaysia are highly diverse, comprised of a multiplicity of species and gear types. The most important industrial fishing gears in Peninsular Malaysia are trawl (*pukat tunda*) and purse seine (*pukat tarik*) nets, where trawl gear harvest demersal (bottom-dwelling) species and purse seines harvest pelagic (surface-dwelling) species.³ Demersal fish account for over 70 percent of the total fish harvested. The west coast fishing grounds are generally muddy and shallow, which facilitates dragging a trawl net on or near the ocean bottom. Trawlers and purse seiners together contributed 84 percent of total fish landings and 74 percent of total wholesale value of fish in Peninsular Malaysia in 1990. Artisanal vessels generated the second highest earnings at the wholesale level, since they caught high-valued demersal fish such as snappers and groupers, but only in small quantities. In contrast, trawlers catch fish indiscriminately, with a highly variable species composition, of which about one-third may be “trash” fish.⁴

The pattern of exploitation of fishery resources is very uneven. About 80 percent of the fish caught are from inshore areas, usually within 20 miles of the coast. The concentrated inshore fishing led to a situation of overfishing (defined here as a level of fishing effort producing a catch over the maximum sustainable yield) off the west coast of the peninsula by the late 1960s, resulting in depletion of the fishery resources. Overfishing has led to an increasing composition of “trash” fish in total landings, reducing marketable output over time.

The 1981 Fisheries Licensing Policy aimed to protect artisanal fisheries and to control capacity through the area license limitation program. The Department of Fisheries determines the number of license granted for different gear, although the actual allocation is determined at the state level. The Department of Fisheries does not issue new licenses for vessels on the west coast except those of 40 GRT and above in the hope of a gradual reduction in fishing effort. Enforcement is difficult, the zones -- especially shrimp-rich inshore zones, are intruded upon, and there are many illegal, unlicensed vessels.⁵ Moreover, some rich shrimp beds extend beyond the restricted geographic zones -- they are straddling stocks -- which allows continued harvesting by trawlers rather

than artisanal fishers.

Malaysian fisheries are divided into four zones. Zone A, which covers all areas within 5 miles from the shoreline, is reserved for traditional fishing gear owner or operated by traditional fishers. Zone B, which covers waters beyond 5 miles to 12 miles from the shoreline, is reserved for vessels with either trawl or purse seine gear and less than 40 gross registered tons (GRT). Zone C, which covers waters beyond 12 miles to 30 miles from the shoreline, is reserved for trawlers and purse seiners less than 40 GRT owned and operated by Malaysian fishers. Zone D, which covers waters beyond 30 miles, is reserved for fishing vessels greater than 70 GRT either totally or partially Malaysian owned. This zoning regulation therefore prohibits trawling within the 5 mile limit and allocates fishing grounds by types of gear, that is, traditional versus commercial fishing gear, size of vessel, and ownership status of the vessel.

The zonal licensing scheme attempts to fairly allocate fishing grounds and resources between the highly efficient trawlers and purse seiners versus the less efficient traditional gears. This scheme is expected to reduce competition and conflict between the operators of the two different gears, especially over the highly valuable shrimp resource. The regulation also aims to reduce over-fishing in the inshore waters.

Although the regulations have been imposed to manage fisheries, in practice the non-compliance and incidence of encroachment by the large-scale gears and even by foreign vessels into the prohibited fishing area is common. The non-compliance coupled with the zonal regulation results in continued over-fishing and conflict over the resource bases. Non-compliance with the zoning regulation poses a serious problem and undermines the effectiveness of fisheries management.

The trawl fishery of concern in this study covers the fishing locality of Kuala Kedah in the state of Kedah in Peninsular Malaysia. Table 1 and portions of Table 4 report summary statistics of this fishery from a representative sample capturing about 25 percent of the vessels (the data sampling process is discussed below). Vessels average 33 Gross Registered Tons (GRT), with a substantial range, from 5 to 65 (Table 1). Horsepower averages 276, also with a substantial range, from 50 to 400 (Table 1). The number of men in a boat averages just slightly under 4, with a range from 2 to 8 (Table 1). The larger vessels are fully capable of fishing in the farthest reaches of the Malaysian Extended Economic Zone whereas the smaller vessels would be confined to innermost Zones. All vessels harvest throughout the year, through all seasons. Most vessels are home ported Tangkang Yard and the rest scattered among Komplek's LKIM (Lembaga Kemajuan Ikan Malaysia), Kampung Masjid Lama, and Kuala Sala (Table 4).

Skippers are generally highly experienced, with a mean of 24 years fishing experience and a mean age of almost 46 years

(Table 1). About one-half of the skippers are Malay and about one-half are Chinese or others (Table 4). About one-half of the skippers own their vessels and about one-half do not (Table 4). The education level is generally at the primary level.

Trip characteristics vary by season (Table 1). In the normal season, vessels average a catch per trip of 908 kg of fish from a trip of almost 22 hours. In the peak season, vessels average a catch of about 1587 kg of fish from a trip of almost 18 hours. In the off season, average catch declines to about 609 kg from a trip of almost 21 hours. In sum, the productivity or catch per unit effort increases from the normal to peak season but declines from the normal to the off season.

4. Empirical model

A fishing vessel's technical efficiency is a measure of its ability to produce relative to the fleet's best-practice frontier, the maximum output possible from a given set of inputs and production technology Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). Technical inefficiency is the deviation of an individual vessel's production from this best-practice frontier. The estimated frontier is stochastic because fishing is sensitive to random factors such as weather, resource availability, and environmental influences (Kirkley *et al.* 1995).

The translog stochastic production frontier, where symmetry conditions have been imposed, is specified by:

$$\begin{aligned} \ln Y = & \alpha_0 + \alpha_1 \ln K + \alpha_2 \ln L + \alpha_3 \ln T \\ & + \alpha_4 \ln K^2 + \alpha_5 \ln L^2 + \alpha_6 \ln T^2 \\ & + \alpha_7 \ln K \ln L + \alpha_8 \ln K \ln T \\ & + \alpha_9 \ln L \ln T + \epsilon. \end{aligned} \quad (1)$$

Y denotes total output (catch) in kilograms as the geometric mean of all species landed where revenue shares serve as weights. The vessel capital stock (K) is a volumetric measure given by vessel gross registered tons (GRT); labor (L) is the number of crew employed per vessel for a fishing trip, including the captain. The hours per trip (T) represents variable input usage (e.g., diesel and/or gasoline, lubricant and/or oil, ice, and miscellaneous variable inputs).

The error term ϵ in Equation (1) is defined as $\epsilon = V - U$. V is a two-sided error term which captures exogenous stochastic shocks and is assumed to be symmetrical and independently and identically distributed as $N(0, \sigma_V^2)$. U is a non-negative term which captures differences in technical inefficiency and is assumed to be an independently distributed non-negative random variable, such that U is the truncation of a normal distribution at zero, with mean $\mu = Z\delta$ and variance σ_U^2 , $N(Z\delta, \sigma_U^2)$.⁶ The independent distribution of V and U allows the separation of noise and technical inefficiency. Z defines a (1xM) vector of explanatory variables associated with the technical inefficiency function, and δ is an (Mx1) vector of unknown parameters to be estimated (Battese and Coelli

1995).⁷ The technical inefficiency function, comprised of the vector of variables Z, is specified as:

$$U = \delta_0 + \delta_1 \text{ EXP} + \delta_2 \text{ HOUSEHOLD} + \delta_3 \text{ CREW} + \delta_4 \text{ D}_{\text{OWN}} + \delta_5 \text{ D}_{\text{EDU}} + \delta_6 \text{ D}_{\text{AREA}} + \delta_7 \text{ D}_{\text{ETHNIC}} + \delta_8 \text{ D}_{\text{OFF}} + \delta_9 \text{ D}_{\text{PEAK}} + \delta_{10} \text{ D}_{\text{SMALL}} + \delta_{11} \text{ D}_{\text{LARGE}} + W,$$

where U is the vessel-level technical inefficiency measure; the random variable W is defined by the truncation of the normal distribution with zero mean and variance σ_U^2 , such that the point of truncation is $-Z\delta$; EXP denotes the captain's years of fishing experience; HOUSEHOLD denotes total household size (in persons, including the captain); and CREW denotes number of persons per vessel (including captain).⁸ The eight D terms are dummy variables equal to one when: the operator does not own the vessel (OWN); the captain has not received formal education (EDU); the vessel is home-ported in Komplek's LKIM, Kampung Masjid Lama, Kuala Sala, or Tangkang Yard (AREA); the captain is Chinese, Indian, or an ethnic group other Malay (ETHNIC); the vessel fishes in the off (monsoon) season (OFF); the vessel fishes in the peak season (PEAK); the vessel is less than or equal to 15 GRT (SMALL); and the vessel is greater than 50 GRT (LARGE). The intercept δ_0 captures the case of a trawl vessel: greater than 15 GRT but less than or equal to 50 GRT which is home-ported in Kuala Kedah; owned and operated by a Malay captain with formal education; and which fishes in the normal season. A random error term W was added to Equation (2) for estimation.

Technical inefficiency for each vessel, following Jondrow et al. (1982), is defined as the expected value of U conditional on the value of ϵ , i.e., $E(U|\epsilon)$. Technical efficiency for each vessel is defined as $TE = \exp(-U) = \exp(-Z\delta - W)$, where exp is the exponential operator (Battese and Coelli 1988).

The stochastic frontier, Equation (1), and the technical inefficiency function, Equation (2), were jointly estimated by maximum likelihood using Frontier 4.1 (Coelli 1996), under the behavioral hypothesis that fishers maximize expected profits (Zellner, Kmenta, and Dreze 1966).⁹ Several hypotheses about the model can be tested using generalized likelihood ratio tests. The first null hypothesis is whether or not technical inefficiency effects are absent, which is specified as: $\gamma = 0$, where $\gamma = \sigma_U^2 / (\sigma_V^2 + \sigma_U^2)$ and lies between 0 and 1, tests whether or not $\sigma_U^2 = 0$. Non-rejection of the null hypothesis, $\gamma = 0$, indicates that the U term should be removed from the model and that the stochastic production frontier is rejected in favor of ordinary least squares estimation of the average production function in which the explanatory variables in technical inefficiency function are included in the production function.¹⁰ The second hypothesis is whether or not the functional form of the stochastic production frontier, Equation (1), is Cobb Douglas. The null hypothesis is $\alpha_4 = \alpha_5 = \dots = \alpha_9 = 0$ in Equation (1). The third hypothesis is

whether the technical inefficiency function, Equation (2), is influenced by the level of explanatory variables. Under the assumption that the inefficiency effects are distributed as a truncated normal, the null hypothesis is that the matrix of parameters, including the intercept term δ_0 , is null such that $\delta_1 = \delta_2 = \dots = \alpha_{11}$.¹¹

4.1. Data

Multistage sampling was applied to obtain the 126 respondents. Fishers were stratified based on gear type and the list of fishing vessels in the area was collected from the fisher co-operative unit office for 1994, the period of the study. The 126 trawl vessels in the sample were selected randomly from a population of 488 trawl vessels in Kedah. The sampling unit was the fisher with a decision-making role while at sea. In other words, he was the fishing master who decided whether or not to fish. Data were obtained for each vessel for the normal, off (monsoon) season, and the peak season, giving a total of 378 observations and a balanced panel data set.

The face-to-face interviews were conducted by undergraduate students in the Faculty of Economics and Management, Universiti Putra Malaysia. The interviewers were selected based on their working experience as an enumerator, subjects or courses taken in their undergraduate programs, and proficiency in the use of local dialect/language. Training was given to all enumerators before they undertook the survey.

5. EMPIRICAL RESULTS

The generalized likelihood ratio tests of the three null hypotheses, summarized in Table 2, indicate that at the one percent level of significance: (1) the stochastic production frontier is appropriate for the sample of data ($H_0: \gamma = 0$ is rejected); (2) the translog functional form is selected for the stochastic production frontier ($H_0: \alpha_4 = \alpha_5 = \dots = \alpha_9 = 0$ is rejected); and (3), the technical inefficiency function is comprised of the vector of explanatory variables ($H_0: \delta_1 = \delta_2 = \dots = \alpha_{11}$ is rejected).

Parameter estimates of the final form of the stochastic production frontier, Equation (1), are reported in Table 3. The distribution of technical efficiency scores, relative to the best practice frontier scores is reported in Table 4 and Figures 1 and 2. Figure 1 illustrates the technical efficiency scores for all vessels over all three seasons. Figure 2 is organized by season and vessel or data management unit – DMU. The top panel gives technical efficiency scores for the peak season, the middle panel gives scores for the off season, and the bottom panel gives scores for the normal season. The scores for each vessel are vertically aligned, so that the score for a vessel in the peak season lies directly above the score for a vessel in the off season, and a vessel's scores for the peak and off seasons are directly above that vessel's score for the normal season.

Perhaps the most salient feature is the wide range of technical efficiency, ranging from 0.01 to 0.95 (Table 4, Figure 1). The efficiency scores are distributed around the mean of 0.49, with, given the sample size of 378 observations, remarkably few vessels in the low and high score tails (Figure 1). The mean of 0.49 across all seasons is lower than those generally found from stochastic frontiers for developing country agriculture (Bravo-Ureta and Pinheiro 1994, Table 1) and the high value found by Squires *et al.* for the Peninsular Malaysian gill net fleet of artisanal fishers. The comparatively low mean level of technical efficiency found in this study contrasts with Schultz's (1964) thesis of "poor and efficient" smallholders and peasants in developing country agriculture.

The frequency distribution over all seasons also differs from that typically found in less developed country agriculture, where the agricultural distribution is typically skewed toward higher efficiency levels (Figure 1). At first blush in this fishery, in contrast, the distribution tends towards the normal (wider intervals would push the distribution towards the normal). The distribution, however, in fact settles down as a hybrid between a normal and a skewing toward the high end due to a peak frequency at a comparatively high level of efficiency. In sum, the vast majority of the Kedah trawlers have comparatively low levels of technical efficiency over all seasons of the year and face substantial scope for technical efficiency gains, given the state of their technology.

The factors affecting technical inefficiency in the model, given the sample data, can be analyzed by the magnitude, algebraic sign, and significance of the estimated coefficients in Equation (2), the technical inefficiency function. Table 5 provides the estimated technical inefficiency function, where the dependent variable is technical inefficiency as opposed to technical efficiency. Thus, a negative sign indicates a *decrease* in technical inefficiency or an *increase* in technical efficiency. The statistically significant variables in the technical inefficiency function are the intercept, ethnicity of the captain, fishing in the off and peak seasons, and a large (> 50 GRT) vessel.

The most striking result is the variation of technical efficiency by season (Table 4, Figure 2). Most vessels are technically efficient (around 0.8) during the peak season, so that there is only one regime of efficiency. In the normal season, there are two efficiency regimes, moderate efficiency (around 0.6) or very low efficiency, with overall efficiency much lower than found during the peak season. Moreover, the lower efficiency regime dominates the higher efficiency regime during the normal season. The normal season efficiency level lies between the levels of the peak (highest) and off (lowest) seasons.

During the off season, there are also two efficiency regimes, but the lower level regime dominates the higher level regime, giving a very low overall efficiency. Resource abundance and

especially availability decline during the off season. The number of hours per trip and mean catch per trip decline compared to the peak and normal seasons, while the number of men in the boat rises. Hence, the source of efficiency decline in the monsoon season is clear: a lower volume of fish are caught by a higher number of persons in the boat.

Technical efficiency rises slightly with vessel size (Table 4). The lowest efficiency vessels average 27 GRT and GRT increases with vessel tonnage to an average of almost 37 for the most efficient vessels. The dummy variable for the largest vessel size class (> 50 GRT) is negative and statistically significant, indicating that vessels of this size class decrease technical inefficiency. Similarly, technical efficiency rises with engine horsepower, from a mean of 227 for the least efficient vessels to a mean of 308 for the most efficient vessels. Along similar lines, crew size increases with technical efficiency for all three seasons (Table 4), although this variable is statistically insignificant in the estimated technical inefficiency function (Table 5).

Technical efficiency varies by ethnicity of the skipper (Tables 4, 5). The dummy variable for Chinese and others skippers is negative and statistically significant in the technical inefficiency function (Table 5). Similarly, the number of Malay skippers declines with increases in efficiency whereas the number of Chinese and other ethnic group skippers rises with increases in efficiency. This result contrasts with those of Squires *et al.* for the Peninsular Malaysian artisanal gill net fishery, where ethnicity of the skipper did not affect efficiency. Chinese skippers were generally the first in the trawl and purse seine fisheries and Malays were comparative late-comers. Mean years of fishing experience does not appreciably differ by technical efficiency class or ethnic group (Tables 4, 5), but the greater length of time for Chinese as a group in this fishery may have led to accumulated knowledge that has been passed down within this group that has not been disseminated outside of it. Among Chinese skippers or fishers, there is also greater networking and sharing of information within the Chinese community as opposed to Malay fishers. Training among the Chinese community also takes place earlier and they were the first to acquire and use modern equipment such as echo sounders and fish detection devices. Squires *et al.* found that participation in a skipper training program did not affect technical efficiency of artisanal gill net fishers, but perhaps in this offshore fishery such a program might find more room for success.

6. CONCLUDING REMARKS

License limitation programs, especially those limiting vessels by areas or zones, form the cornerstone for the management and sustainable resource use of many fisheries in the tropics. Because tropical ecosystems are characterized by highly diverse species variety and complex interactions among

species and with their habitat, area license programs are likely to remain the linchpin to fisheries management in most of these fisheries. Moreover, conventional management measures, such as catch quotas, have generally proven ineffective in fisheries of these countries (FAO 1983).

Skipper skill, defined as the technical efficiency of a skipper and the skipper's vessel, represents the most difficult component of fishing capacity to monitor, measure, and manage in license limitation programs and in management by Total Allowable Catches. This study provided one of the few pieces of empirical evidence on the magnitude of variation in skipper skill, interpreted as technical efficiency, and the factors that can affect it.

In the Kedah trawl fishery, skipper characteristics other than ethnicity did not significantly affect technical efficiency and skipper skill. Hence, there does not appear to be any readily observed characteristic pertaining to skipper skill to monitor and regulate. This finding militates against regulating skipper skill to control expansions in fishing capacity that can happen under license limitation.

Season of the year was the most salient factor affecting skipper skill and technical efficiency. Regulating fishing by season of the year is biologically very effective when a season is a spawning period, so that protecting female spawning fish by limiting or preventing catches in that season increases the probability of a larger fish stock in the future. Limiting or halting catches in a particular season as a means to reach a sustainable yield target catch, however, may be less tractable since most trawlers are full-time fishers and require the incomes to finance vessel and crew payments. Moreover, limiting catches in the off season would increase efficiency but would prevent catches when prices can reach their highest and when there are the least available alternative sources of employment due to the inclement weather. Finally, other employment choices except in the fishery are not affected by weather.

In sum, the results indicate that a skipper training program for the least efficient skippers may be called for to meet the objectives of equity and fairness as expressed in the New Economic Policy and its successor, the New Development Plan. Such a training program would also be consistent with the one of the initial aims of the license limitation program, which was to promote equity among all ethnic groups in Malaysian society. Moreover, the license limitation program was not based solely on resource conservation, because major importance was also attached to economic, social and political aspects (Majid 1985). Jahara observed that the objective of allocating fishing grounds represented a strong emphasis on equity, and that the issue was as much politics as equitable allocation of fishery resources between highly efficient trawlers and less efficient small-scale fishers. It is only one more simple step forward to raise the level of efficiency of all

skippers, regardless of ethnicity, to a minimum standard, thereby contributing to equity and hence the objectives of the license limitation program and the New Development Plan.

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Figure 1. Frequency of Technical Efficiencies

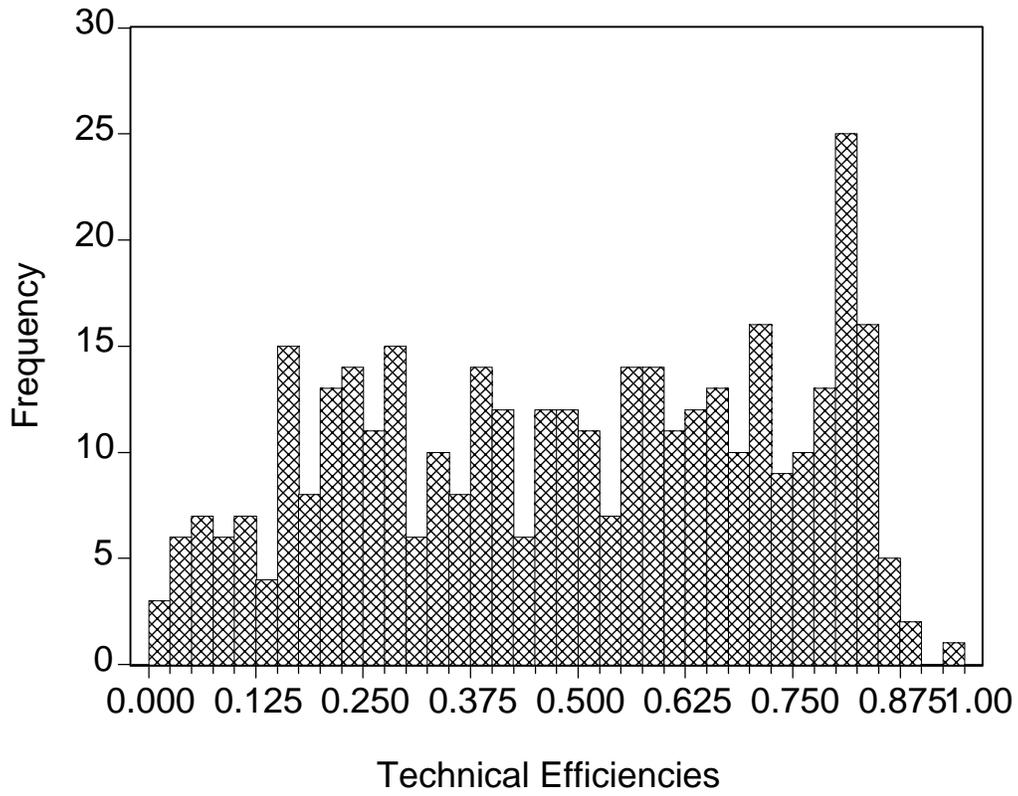


Figure 2. Technical Efficiency over Season by DMU

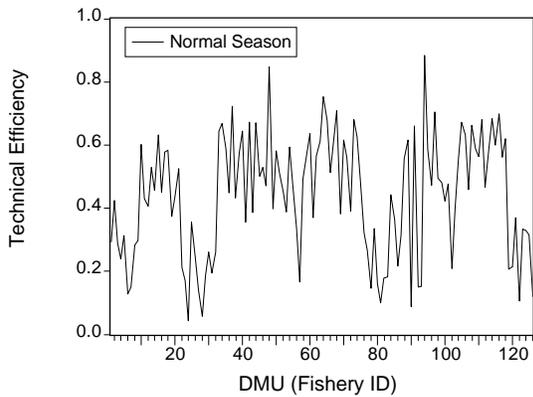
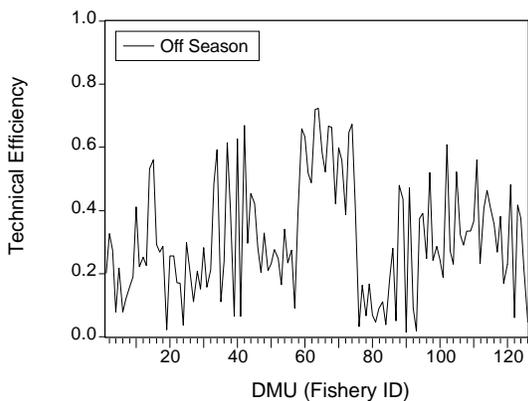
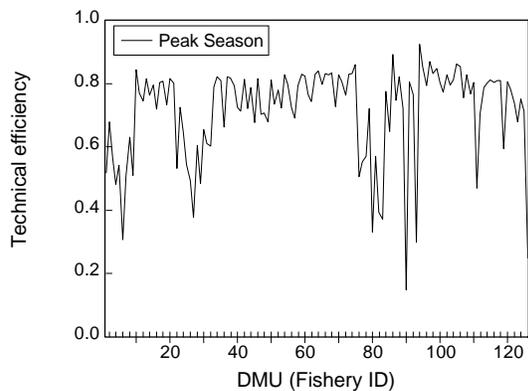


Table 1. Summary Statistics of the Data

Vessel and fishing characteristics	Mean	Median	Maximum	Minimum	Standard Deviation
Location	1.52	1	5	1	1.26
Years experience as fisher	24.22	25	50	8	8.05
Age	45.73	45	76	19	8.17
Ethnic group	1.59	2	4	1	0.62
Boat Ownership	1.56	2	2	1	0.50
Tonnage	33.47	33	65	5	12.62
Horse power	276.15	250	400	50	82.15
Schooling experience	1.06	1	2	1	0.23
Household size	5.99	6	18	0	2.25
No. of family members are working	2.25	2	14	0	2.26
No. of children schooling	1.91	2	6	0	1.50
Peak season					
No. of hours/trip	17.65	12.5	72	2	13.30
Average kg catch/trip	1586.82	1300	20000	100	2007.56
No. of men in boat/trip	3.94	4	6	2	0.88
Off season					
No. of hours/trip	20.59	14.5	70	6	15.02
Average kg catch/trip	608.53	325	3500	10	634.02
No. of men in boat/trip	3.98	4	8	2	0.96
Normal Season					
No. of hours/trip	21.75	14	72	6.4	15.58
Average kg catch/trip	907.54	675	10000	10	1134.59
No. of men in boat/trip	3.94	4	6	2	0.88

Table 2. Generalized Likelihood Ratio Tests of Hypotheses for Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Function

Null Hypothesis	Likelihood Ratio	df	Critical Value (5%)	Critical Value (1%)
1. $\gamma = 0$ (No stochastic frontier)	193.504	2	5.138	8.273
2. $\alpha = \alpha_5 = \dots = \alpha_9 = 0$ (Cobb-Douglas frontier)	32.599	6	12.592	16.812
3. $\delta_1 = \delta_2 = \dots = \delta_{11} = 0$ (No technical inefficiency fn.)	157.110	11	19.675	24.725

- Notes: 1. Test for $\gamma = 0$ follows mixed chi-square distribution with critical values found in Table 1 of Kodde and Palm [1986].
 2. Df = degrees of freedom.
 3. A truncated-normal distribution is assumed for the technical inefficiency error term.

Table 3. Parameter Estimates of the Stochastic Production Frontier

Variables	Parameter	Coefficient	Std. Error	t-Ratio
Intercept	α_0	-0.81	0.32	-0.25
ln K	α_1	1.75	1.30	1.35
ln L	α_2	6.50	2.49	2.61
ln T	α_3	-0.79	0.73	-1.08
ln K ²	α_4	-0.42	0.20	-2.13
ln L ²	α_5	-2.29	0.97	-2.37
ln T ²	α_6	0.31	0.09	3.55
ln K* ln L	α_7	0.92	0.82	1.12
ln K*ln T	α_8	0.28	0.23	1.25
ln L*ln T	α_9	-1.26	0.34	-3.71
σ^2	0.94	0.18	5.22	
γ	0.71	0.07	10.03	
log-likelihood			-0.428	
No. of observations			378	

Notes: 1. $K = \text{GRT (Tonnage)}$, $L = \text{No. of men in boat/trip}$, $T = \text{No. of hours/trips}$.
 2. Translog functional form.

Table 4. Frequency Distribution of Technical Efficiency Scores

Range	[0,0.2)	[0.2,0.4)	[0.4,0.6)	[0.6,0.8)	[0.8,1.0]
Total count	56	91	88	94	49
Location (count)					
(1) Kuala Kedah	46	75	73	82	42
(2) Kompleks	3	1	2	0	0
(3) Kampung Masjid Lama	3	4	0	2	0
(4) Kuala Sala	4	3	1	1	0
(5) Tangkong Yard	0	8	12	9	7
Years experience as fisher (mean)	25.53	24.42	23.27	24.73	23.06
Age (mean)	47.11	45.21	44.88	46.68	44.84
Ethnic group (count)					
(1) Melayu	51	52	34	32	5
(2) Chinese	5	39	52	57	42
(4) Others	0	0	2	5	2
Boat Ownership (count)					
(1) boat owner	35	48	38	34	13
(2) Others	21	43	50	60	36
Tonnage (mean)	27.28	31.43	35.67	35.26	36.96
Horse power (mean)	227.29	263.24	287.61	290.27	307.96
Schooling experience (mean)	1.05	1.08	1.05	1.05	1.04
Household size (mean)	6.21	6.35	5.93	5.82	5.49
No. of family members are working	2.16	2.27	2.26	2.33	2.10
No. of children schooling	2.16	2.05	2.02	1.64	1.69
Peak season (mean)					
Count	1	7	16	55	47
No. of hours/trip	24.00	24.00	16.53	15.31	19.68
Average kg catch/trip	200.00	264.00	316.88	1229.44	2663.83
No. of men in boat/trip	3.00	3.57	3.38	3.98	4.15
Off season (mean)					
Count	36	51	27	12	na
No. of hours/trip	16.99	19.13	25.59	26.33	
Average kg catch/trip	89.86	435.88	1118.89	1750.00	
No. of men in boat/trip	3.53	4.06	4.19	4.58	
Normal Season (mean)					
Count	19	33	45	27	2
No. of hours/trip	17.68	15.24	22.20	32.81	8.00
Average kg catch/trip	125.79	366.37	930.44	1592.59	7500.00
No. of men in boat/trip	3.37	3.64	4.16	4.29	4.50

Mean: 0.49 Minimum: 0.01 Maximum: 0.95 Std.Dev.:0.24

Notes: 1. Measures are in terms of efficiency and not inefficiency.

Table 5. Estimated Technical Inefficiency Function

Variable	Coefficient	St. Error	t-Ratio
Intercept	1.97	0.93	2.12
Yeas experience as fisher	0.02	0.01	1.64
Household size (in persons)	-0.06	0.04	-1.37
No. of men in boat/trip	-0.14	0.20	-0.71
Dummy variables for:			
Boat ownership	-0.35	0.20	-1.72
Formal educaton	0.08	0.41	0.20
Area of home port	0.05	0.29	0.17
Ethnicity of captain	-1.30	0.29	-4.55
Off season	0.72	0.20	3.58
Peak season	-1.77	0.60	-2.95
Small Vessel	-0.34	0.37	-0.93
Large Vessel	-1.18	0.47	2.51

- Notes:
1. Estimated coefficients from a truncated normal distribution for technical inefficiency error term and translog stochastic production frontier.
 2. Coefficients obtained from estimation of Equation (2) where technical inefficiency is the dependent variable.
 3. Small vessel: < 15 GRT and Large vessel > 50 GRT

Endnotes

¹ See Wilen (1988) and Townsend (1990) for discussions of license limitation programs in fisheries. See Lawson (1984), Loaza and Sprague (1992), and Platteau (1989) for general discussions and overviews of fisheries development.

² This section draws from Ishak (1991, 1994), Ishak, Kusairi Mohammad Noh, Nik Mustapha Raja Abdullah, and Kuperan (1991), Jahara (1988), Kuperan (1993), Majid (1985), Ooi (1990), Susilowati (1998), Teo (1998), and Vincent, Rozali, and Jahara (1997).

³ Demersal species are bottom-dwelling and are especially abundant in inshore waters, since they use light penetration to search for food, while pelagic species tend to be surface feeders, moving in large shoals, and are usually found offshore (Ishak 1994). In tropical waters, where thousands of fish species are found, the habits of some fish are indeterminate, and hence vaguely categorized as semi-pelagic.

⁴ Trash fish include an assortment of juveniles of commercial and non-commercial species that are unsuitable for human consumption. Due to their small size, trash fish are processed into fish meal and sold as animal feed or turned into fertilizer. Trash fish can also include species that are unwanted, such as finfish caught while harvesting shrimps. These trash fish jointly harvested with shrimps are often discarded at sea.

⁵ The first serious analysis of the zoning regulation and non-compliance in Malaysia and the zoning regulation is Kuperan and Sutinen (1998). Susilowati (1998) gives a recent analysis and discussion of enforcement. She finds a very high violation rate.

⁶ The truncated normal distribution was originally proposed by Stevenson (1980).

⁷ Kumbhakar, Ghosh, and McGuckin (1991) and Reifschneider and Stevenson (1991) first noted the inconsistency between inefficiency effects if in the first stage the error is independently and identically distributed and the predicted inefficiency effects in the second stage are specified as a function of a number of firm-specific factors (which implies that they are not identically distributed unless all the coefficients of the factors are simultaneously equal to zero). The two-stage procedure is unlikely to provide estimates which are as efficient as those that are obtained from the one-step estimation procedure (Coelli 1996).

⁸ Household size is included as a proxy variable to capture sociological impacts from family size.

⁹ The specification of technical inefficiency as unexpected and unknown, or as expected and foreseen, when the firm chooses its inputs affects the specification and estimation of the production function (Kumbhakar 1987). Given the overwhelming importance of “captain’s skill” in locating and catching fish and the inherent stochastic effects from weather, temperature, and biological variations in fishing, it is likely that technical inefficiency that is unforeseen is more important than the foreseen. The point is that technical inefficiency is likely to be never entirely foreseen or unforeseen, but in fishing, technical inefficiency is more likely to be unexpected and unknown. Thus we specify the technical inefficiency as unexpected or unforeseen. Given unknown and unexpected technical inefficiency, the argument of expected profit maximization (Zellner, Kmenta, and Dreze 1966) can be used to treat inputs as exogenous (Kumbhakar 1987, p. 336). If technical inefficiency is known to the firm, estimates of the production function parameters obtained directly from the profit function will be inconsistent.

¹⁰ Any generalized likelihood ratio statistic associated with a null hypothesis involving the γ parameter has a mixed chi-square distribution because the restriction defines a point on the boundary of the parameter space (Coelli 1996). The critical values are given in Table 1 of Kodde and Palm (1986). The number of restrictions, and hence the degrees of freedom for the null hypothesis $\gamma = 0$, is the difference in the number of parameters in the test of the OLS model versus the stochastic production frontier, equal to one for γ , one for μ with the truncated normal (associated with δ_0 , the intercept of the technical inefficiency function) plus the number of terms in the technical inefficiency function, excepting δ_0 , which would not enter the traditional mean response function (Battese and Coelli 1995, footnote 6). In this case, all variables in Z , except δ_0 , would enter the translog production function as log-linear control variables (such as OD), so that the degrees of freedom for $H_0: \gamma = 0$ is two.

¹¹ Not including an intercept parameter (δ_0) in the mean ($Z_i \delta$) may result in the estimators of the δ -parameters, associated with the Z -variables, being biased and the shape of the the distributions of the inefficiency effects, U_i , being unnecessarily restricted (Battese and Coelli 1995). Battese and Coelli (1995) note that when the Z vector has the value 1 and the coefficients of all other elements of Z are 0, Stevenson’s (1980) model is represented. The intercept δ_0 in the technical inefficiency function will have the same interpretation as the μ parameter of Stevenson’s (1980) model (Coelli 1996).